Project number	5
Name/title of the PhD course	Geoscience & Engineering / Applied Mathematics
Name/Title of the PhD project	*Integrated Numerical-Experimental analyses of the safety of porous rocks under cyclic loading*
Recruiting organisation and Department/Faculty of reference	**TU Delft** is the oldest, and with 25,000 students and 6000 employees, also the largest technical university of the Netherlands. The common mission of the 8 different faculties (offering 16 bachelor's and more than 30 master's programs) is: impact for a better society. TU Delft is home to one of the world's leading Geoscience and Engineering departments with subsurface storage as one of the key strategic multidisciplinary themes. The key scientific expertise includes characterization, modelling, simulation, monitoring, optimization and safety assessments of subsurface formations. Part of the training of the PhD students will be provided by the Delft Advanced Reservoir Simulation (DARSim) research group. DARSim is established in 2013 for development of advanced modelling and simulation methods for complex processes in the subsurface geological formations. In addition, the PhD student will have access to the state-of-the-art Laboratory of Geoscience & Engineering which is equipped with highly advanced instrumentations and set-ups to qualify and quantify chemical and physical processes in rocks and soils under deep and shallow in-situ conditions. Experimental equipment key to the proposed research project are the tri-axial stress/strain devices.
Scientific context and Objetives	Assessment of the caprock integrity is one of the crucial aspects of the successful underground hydrogen storage. This requires quantification of the elastic/plastic behavior of the caprock samples, undergone the field-relevant stress fluctuations. Beside performing experiments, conducting numerical simulation plays a crucial role. Very recently at TU Delft we have performed such a study for porous sandstone rocks [Naderloo et al., J of Energy Storage, 2023]. In this project, we aim to extend the state-of-the-art by analyzing the caprocks. We hold state-of-the-art lab and numerical simulation capacities in-house, which enable the PhD candidate to advance the science and engineering knowledge of the field effectively.
Expected Results	Assessment of caprock integrity and reservoir porous rocks (sandstone) elasto-plastic characteristics under cyclic loading relevant for H2 storage.
Secondment opportunities	UEDIN, K Edlmann (6 months, M24-30): R5 will join the HyStorPor team to undertake (reactive) flow-through experiments with H2/brine/bacteria on the same rock using the facilities at UEDIN to test how this effects the geo-mechanical characteristics. Shell (3 months, scattered across second year).
Brief CV of main Supervisor	Hadi Hajibeygi, associate Professor, leader of TU Delft Subsurface Storage Program, with long-term experience in supervising PhDs: 6 PhD Students graduated, currently advising 9 PhDs.
Publications	1. M Naderloo, KR Kumar, E Hernandez, H Hajibeygi, A Barnhoorn, Experimental and numerical investigation of sandstone deformation under cycling loading relevant for underground energy storage, Journal of Energy Storage 64 (2023) 107198. https://doi.org/10.1016/j.est.2023.107198 2. S Krevor, H de Coninck, S Gasda, N Singh Ghaleigh, V de Gooyert, H Hajibeygi, R Juanes, J Neufeld, J Roberts & F Swennenhuis, Subsurface carbon dioxide and hydrogen storage for a sustainable energy future, Nature Review Earth Environ (2023). https://doi.org/10.1038/s43017-022-00376-8 3. WA van Rooijen, P Habibi, K Xu, P Dey, TJH Vlugt, H Hajibeygi, OA Moultos, Interfacial Tensions, Solubilities, and Transport Properties of the H2/H2O/NaCl System: A Molecular Simulation Study, Journal of Chemical & Engineering Data (2023) https://doi.org/10.1021/acs.jced.2c00707
Projects participation	1. Project ADMIRE, funded by the Dutch National Science Foundation (€1m), 2019 – 2025. 2. Project SafeInCave, fudned by Shell (€500k) 3. Project Science4Steer, funded by the Dutch National Science Foundation (€1.4m), 2019 – 2024. 4. Project EU ACT SHARP, €750k 5. Energi Simulation Chair, endowment €120k/year, since 2022—present.